Science and technology should play a strategic role in Brazil, given the need to improve productivity in the economy, to deal with problems of poverty, education, health and environment degradation, and to participate more fully in an integrated world economy and society.

FUNDAÇÃO GETULIO VARGAS
EDITORA

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A NEW POLICY FOR A GLOBAL WORLD

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Volume 1

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Summary

Comments on "Science and Technology in Brazil"

*Michael Gibbons**

There is much good sense in the paper under discussion this morning. The problems facing Brazil today and how it got there are presented clearly and plausibly. In summary, the scientific, technological and educational developments established in the seventies have begun to stutter. According to the paper, the reason for this is primarily economic. Brazil has fallen on hard times; economic growth has collapsed with the recession, inflation rocketed, and as a consequence most of the major institutions associated with the development of a robust national scientific and tehnological capability — government research establishments and universities — are in difficulty. Original policies aimed to establish Brazil's scientific and technological capability no longer seem to be working. Links with industry are weak. Indeed industry seems to be a relatively poor performer of R&D. The thrust of the paper is to develop new policies which face squarely the economic realities of the nineties.

At the core of the paper are recommendations for a three-pronged S&T policy. The basic idea is to put Brazil's scientific and technological institutions back on an even keel by providing separate funding mechanisms for basic research, applied research/technology and education. The aim is to strengthen the universities as the prime providers of basic research and of highly qualified manpower while, at the same time, providing a separate flow of funds for the country's nest of research institutions — the so-called associated laboratory scheme. Difficulties noted include the growth of bureaucracy in the previous regime, the quality of the peer review system, and the reluctance of industry to support R&D out of its own funds.

All of this is plain good sense. But the three-pronged policy aimed at revitalising the scientific and technological institutions of the country has a degree of distinctness that carries the danger of a separation amongst knowledge producing institutions which need to be highly interactive. One consequence of this might be to encourage the persistence of an essentially science-push model of economic regeneration. This, at precisely the time when linear models of innovation have been descredited and when the production of scientific and technological knowledge has become increasingly inter-connected and global. To be sure the policy paper does not recommend institutional separation. Indeed it recognises that pure and applied science now overlap. This is acknowledged in the paper: "The fact

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that the basic science, applied R&D and high level technical education are very often indistinguishable, and take place simultaneously in the same institutions, does not mean that they should not be treated separately in terms of their supporting mechanisms, working from different perspectives and with different approaches". True enough but funding mechanisms have a way of acquiring a life of their own and constant vigilance will be required if the conditions which prevail in the production of science and technology are not explicity recognised.

The key insight is that S&T policy must be related to industrial policy. In fact, what is needed in Brazil is a national innovation policy because the notion of innovation carries with it the idea that a set of relationships are involved and that they must function over an extended time period; innovation policy is an integrationist policy. The premise of this policy should be to get industry moving and moving under its own steam. To do this the appropriate S&T policies should be functionally related to the level of competence of each particular sector. No country, even the wealthiest, can any longer afford to support a comprehensive S&T base in the hope that economic growth will somehow follow. By contrast, around the world science policies are now conceived in relation to technology and industrial policy. This aspect of S&T policy seems to me undeveloped in the paper under discussion. Following Krugman, and eschewing the current hype around competitiveness, national innovation policy should be guided by the assumption that "the coming struggle in which each big economy will succeed or fail [will be] based on its own efforts, pretty much independently of how well the others do" (Krugman, 1994). If he is right, then the basis of the future independence must lie with the performance of the country's wealth creating institutions. If they are working correctly, the rest will follow. The danger in the current formulation is that a fresh attempt will be made to strengthen the knowledge producing institutions independently of the wealth creating ones.

The idea of orienting S&T policy closely with industry is not a popular one. Scientists, in particular, are always quick to point out the dangers that will arise in terms of future discoveries and manpower provision if the scientific enterprise is not supported vigorously. But there will be no support at all for science if national firms cannot generate wealth in the first place. And overwhelmingly, wealth is generated by applying existing knowledge, not by generating new knowledge (Branscomb, 1993).

This is true in all sectors of manufacturing industry at all times. What differs is the types of knowledge needed. Clearly there are differences in the knowledge requirements of a world class pharmaceutical firm and a mechanical engineering firm operating in a remote corner of a developing economy. But there can be no argument that, in both cases, knowledge is necessary and if it is to be utilized it must be assimilated and develop largely inside in the company itself.

Brazilian S&T policy needs to be sensitive to the different knowledge requirements of its particular sectors. In relatively few of these will the company be operating at the frontier of world class innovation. The question is, given that

the firms in a particular sector are likely to be relatively laggard, how is it possible to move from that position closer to the market leaders? How can they begin from where they are in terms of technological competence into a position where latest science and technology can be appropriated? In this, what is usually termed R&D should come towards the end of a rather long and multistage process — as a result of previous industrial innovation — not at the beginning, as the engine on which all expectations are concentrated. We need policies to support some kind of "reverse linear model".

Some experience of other countries

We can begin from experience in the United States. Here there has been a good deal of soul searching over the policies of the large national companies who in the sixties began siting heir manufacturing operations offshore — in low wage economies. It now appears that the firms in some of these countries are now able to compete very effectively with the United States in precisely those markets where initially foreign direct investment (FDI) was placed. To sum up a rather complex set of histories, in the transfer to low wage economies, the Americans have "lost control over what they used to make". How can this be? How can a relatively backward economy — at least in terms of technology and skills — acquire the knowledge and skills to effectively displace the parent company? Americans are worried about this loss of control over what they used to make. Many examples are given in an MIT study entitled *Made in America* (1989) and in *Manufacture Matters* (Cohen & Zysman, 1987). The point of introducing this work here is simply to point out that it seems to be possible for some firms to begin in the middle of the innovation cycle with the mature technologies of an established design configuration, and with a relatively low level of technical and marketing competence move on to become one of the leading players.

Another example, this time from the United Kingdom. During the seventies the motor vehicle and television tube production by United Kingdom firms virtually ceased. Twenty years later Britain is a world leader in the manufacture and export of both cars and TV tubes. Manufacturing is not, in the main, carried out by British firms but by Japanese ones who have invested in Britain. How was this accomplished? In a recent paper, D. Eltis has used these two examples for the purpose of showing that FDI can have beneficial effects in a sector that has lost the technology and skills to compete internationally in the manufacture of complex products. The Japanese firms did not begin by carrying out R&D in Britain. Rather, they established the most sophisticated plant, hired British workers, and trained them in its use. The effect of a high technology plant in its midst has, among other things, the effect of forcing suppliers to innovate and of building up local cultures of excellence related to the main products — in this case motor cars and television tubes. Although evaluating the benefit of such FDI is a com-

plex matter, it would be interesting to explore the full effects of these investments on the local culture of innovation.

The experience of the East Asian Dragons provides a range of dramatic examples of innovation in the electronics sector where companies were able to join in the middle of the game, as it were. In some of these FDI was important, in others it wasn't. Although foreign investment is dealt with most extensively in the literature on technology transfer, historically FDI has contributed with only relatively little of the capital formation in the Dragons. The two largest economies, Korea and Taiwan, have been fairly closed to FDI, with governments exercising strict control. FDI contributed around 2 per cent to Korea's total capital formation during the period of 1976 to 1987 (James). In the case of Taiwan, between 1965 and 1985, FDI oscillated between 1.35 per cent and 4.32 per cent of total capital formation and between 2.5 per cent and 5.47 per cent of total private capital formation per annum (Dahlman & Sananikone, 1990). In contrast, FDI contributed around 18 per cent to Hong Kong's total capital formation during the period (Hobday, 1991). In the case of the Dragons, what happened, if not FDI? The short answer is that the economic transformation of those economies rests upon a whole range of measures which encourage market growth and technology assimilation. The principal mechanisms are: joint ventures, licensing, imitation, sub-contracting original equipment manufacturer (OEM), company acquisitions and strategic partnerships. Of these the most important, particularly in the early stages of industrialization, appear to be OEM agreements.

A definition of OEM

Original equipment manufacturer (OEM) is a specific form of sub-contract. Like a joint venture it requires close connection with the foreign partner. Under OEM deals, the local firm produces a good to the exact specification of the foreign company. The foreign firm then markets the product through its own distribution channels, under its own brand name. OEM often involves the foreign partner in the selection of equipment, training of managers, engineers, and workers. It is to be contrasted with own design and manufacture (ODM), where the local firm designs the product to be sold by the TNC.

What are the common factors in these very diverse experiences? I believe a key factor is that through these various mechanisms firms acquire and assimilate knowledge; that is, they learn. A second factor is that learning must begin from where the firms are, with the resources that are available. Although the level may be low to begin with, it doesn't need to stay there and, in the case of the East Asian Dragons, it certainly didn't. Thirdly, the learning took place locally and cumulatively. Fourthly, the locus of action is the national corps of entrepreneurs and managers.

The centrality of learning is important. We know that much technology transfer can lead to disappointing results, often because the local learning capability is lacking. More positively, from the point of view of Brazil, we know from a number of American studies that United States firms gave away important informational knowledge by underestimating the power of local learning capability (Cohen & Zysman, 1987). It might be useful just to remind ourselves that the learning in question is particular to specific markets and if the focus was more on the product — what is learned — than the process — learning — then we would be talking about technology and its aquisition. I hope that is clear.

Studies of learning attempt to show how technological know-how is acquired within firms and related institutions. Learning refers to the mechanisms by which firms generate capabilities in products, processes and related organizational structures. Learning is largely embodied in the skills of the workforce and managers. Malerba (1992) demonstrates the importance of learning to firm-level incremental technical change, productivity change and to different types of product and process improvement. Learning normally involves substantial and deliberate effort and investment on the part of the firm. Developing country research has shown that learning is important to technological and institutional progress (Fransman & King, 1984). Dahlman et al. (1985) show that learning develops in sequence, shifting from production to investment to innovation capabilities. Similarly, Lall (1982) discusses the passage from elementary to intermediate advanced learning. Lall also shows how non-technological learning is important to organizational development (e.g. marketing and managerial skills).

However, few of these studies of developing countries relate technological learning to export marketing channels. Nor do they examine firm strategies towards learning, preferring instead to describe general characteristics of learning at the industrial level. As a "first approximation" of how the process of technology assimilation links to marketing development, the model (developed below) may provide a useful framework.

The question is: if the game of international competitiveness has a technological dimension, how do latecomers join? Can they start towards the end of the product cycle and hope to move to a position of dominance at some later time? It is a chronic problem. Do the innovators always have to be in the lead, and are the followers always laggard? The clear answer is, No! Whatever else it may be, international competitiveness is a complex game, but, equally, it is unrealistic to expect to be able to jump into the lead in a particular sector without the proper preparation. No policy is likely to be very effective if it neglects the fact that technological innovation is not a once off acomplishment, but an unending process aimed at adjusting technological capability to continuously shifting market needs. The path to economic prosperity is dynamic and path dependent. This means that learning — technology acquisition — must be continuous and incremental, and firms have no other option but to begin from where they are. For some governments, this is a hard lesson to learn.

In the next section, a simple model is presented, based on some recent work of Hobday and others. The model is based on the by now clearly established fact that successful innovation is characterized by a close and continuous connection between technology development and the market. The premise, therefore, is that for latecomer firms the problem is to find a way to join an on-going process of technology-market interactions. The challenge is to do this beginning with relatively low level technical resources and with very weak market information. Current innovation theories would suggest that the key to this process for firms to get in early on a new innovation/product cycle and through learning move from these uncertain beginnings to capture economic benefits which will only emerge as product and process technologies mature. Many contemporary S&T policies accept this view. Hence the interest in generic technologies and large demonstrator projects. Such policies are R&D driven. They are intended to set the stage for firms to get in early in the next innovation cycle, but would seem to exclude latecomer firms precisely because they would lack the knowledge and skill to assimilate the knowledge produced in these R&D driven projects. In the model developed below, it is proposed to show that latecomer firms can and often do start in the mature technology stage and move "backwards" to the R&D and design stage.

Export-led technology development — a simple model for latecomer firms

A latecomer firm is defined as one located in a developing country, outside the locus of world innovation and R&D. Such a firm does not face demanding buyers in its domestic markets which, as Porter (1990) shows, is often a key factor in competitive performance. Similarly, the latecomer firm is cut off from leading industrial clusters and important marketing networks. The firm typically suffers from lack of related support industries and a poorly developed technological infrastructure. To prosper, the latecomer must overcome these difficulties (Hobday, 1991).

Market development

The left hand column of the table summarizes a five stage technology-marketing model which is based upon learning as the prime mode of technology assimilation (see notes). Regarding both marketing and technology, the model does not assume any rigid or automatic stages of development. Progress depends primarily on the efforts of local firms and the opportunities afforded by foreign buyers. Some of the stages may occur concurrently as in complex innovation models and there may be feedback loops between earlier and later stages. External factors (e.g. policy actions and the state of the macro-economy) will impinge directly on the process. Many of the normal criticisms of innovation models apply to this scheme (Forrest, 1991).

The latecomer firm progressively internalizes the marketing skills and functions initially carried out by the foreign buyer or manufacturer.

— In the first stage the latecomer is entirely dependent upon buyers for product design skills, marketing, distribution and quality control. The local firm simply sells low cost production capacity.

— During stages 2 to 5 the latecomer firm assimilates more and more complex marketing functions. Spurred on by the prospect of growth and higher value-added activities, the firm learns how to conduct its own sales and marketing.

— It progressively broadens its range of customers and improves the packaging and quality of its products.

— By stage 5 the latecomer firm will have developed its own brand design which it will sell directly to customers overseas: it is no longer dependent on the distribution channels of foreign buyers and manufacturers. By this stage the latecomer will be indistinguishable from the leading firms in the West and Japan (see notes).

Technological assimilation

The right hand column of the table adds a technology dimension to the marketing model to suggest how successful latecomer firms gradually learn the techniques of manufacturing. (The technology scheme is based on interviews carried out during 1992 and 1993 with firms in each of the four Dragons, and a body of research into technological learning and developing countries.)

— In stage 1, it is likely that early NIC entrants begin with simple assembly skills and later assimilate incremental process capabilities. As their capacity expands and numbers of customers increase, they will need to learn how to control the quality and speed of production. During the early stages, firms are likely to remain dependent on outside sources of technology. However, technicians will begin to internalize key production skills.

— During stages 2 and 3, the latecomer firm will gain more and more control over its production process, spurred on by export market opportunities. By acquiring product and process capabilities it will be able to sell more higher quality products to a larger base of customers, bringing the advantages of low cost engineering and management to the market.

— The latecomer entrepreneur recognises that unless the firm goes through a series of difficult technology learning transitions it will remain "trapped" in the capacity export stage.

— By stage 4, the firm will embody sufficient skills to develop new products and processes. The latecomer will have surmounted its technological dependency in terms of product design, quality control and process engineering. It may have already forged links with capital goods suppliers and may conduct R&D into new products and processes.

— In stage 5, the NIC firm will have developed advanced skills and R&D capabilities. Technologically it will be indistinguishable from world market leaders. It will have successfully progressed to the higher stages of product and process development and will compete head on with the world leaders.

According to the simple model, early latecomer firms enter at the mature, standardized end of the product life cycle and cumulatively assimilate technology by internal learning. With each wave of new innovations that catch up little by little, closing the technology gap between themselves and the market leaders. They therefore travel backwards along the technology life cycle, reversing the "traditional" path of technology development, shifting fom mature to earlier stages. In doing so, latecomer firms are able to gradually overcome their distance from the world technology frontier and compensate for the lack of demanding local users and consumers. Not all firms go through all stages. As the quality of the local infrastructure improves, new entrants are able to jump in at the later stages, responding to factor costs, market developments and the availability of skilled engineers and managers.

There may not always be systematic, causal links between the stages of technology and market development. It is theoretically possible for a firm to acquire advanced technological skills but to still remain at the early stage of marketing — or vice versa. However, manufacturing firms in the NICs tend to improve both their technology and marketing capabilities simultaneously. Marketing skills are needed for firms to capture value added associated with packaging, distribution, brand awareness and after sales service. Often these activities are more lucrative than manufacturing. Marketing is also needed for firms to expand their range of customers and determine the direction of their future business. Similarly, technological know-how is needed to develop new products and improve the efficiency of production. Firms have an incentive to expand their value added opportunities, to manage and reduce their dependency on foreign sources and to respond to competition from other latecomers. These processes require the internal acquisition of a range of marketing and technological skills.

In some of the stages there may be a direct link between market and technology. For instance, to achieve the advanced stage of product marketing push, firms will need sufficient R&D capabilities to convert market signals into innovative

new products. Similarly, when shifting from stage 1 to stage 2, firms will need to internalize process skills to expand production capacity, shorten delivery times and improve product quality.

Most importantly, the technology and marketing channels are often one and the same. For instance, under sales and exporting arrangements such as OEM, joint ventures and licensing, latecomer firms are presented with a technology transfer mechanism. Under OEM arrangements, the foreign corporation not only buys finished goods for export, but it will often supply technical specifications, training and advice on production and management. TNCs are often willing to assist in local assimilative efforts under OEM because they depend on the quality, delivery and price of the final output. The market-technology channels established under OEM are often long term. They allow latecomer firms to overcome initial barriers to entry and they supply the vital market information needed for local firms to target investments in technology and skills.

To sum up, in the above scheme, exports "pull" forward the technology of latecomer firms. Through OEM and other channels, export demand acts as a focussing device for technological investments and forces the pace of progress. Local competition stimulates the process as export leaders are imitated by followers. And, as the following evidence shows, firms do not simply "keep up", but actually "catch up" as time progresses (World Bank, 1993).

Application: the case of the East Asian Dragons

Historial data from each of the four Dragons lend some support to the simple export-led technology development model put forward above. The evidence also illustrates the importance of assimilative learning efforts on the part of latecomer firms in electronics. Indigenous firms engaged in rapid technological learning under OEM, sub-contracting and other arrangements. Export-led market growth was closely coupled with technology assimilation through foreign channels of technology transfer including FDI, joint ventures, foreign buyers, licensing and OEM arrangements. These concrete institutional mechanisms enabled local firms to couple export market growth with in-house technological learning.

Through FDI foreign manufactures provided initial examples for local firms to imitate (e.g. Anam of Korea). TNCs helped start up the electronics industries in each of the four countries, providing a source of training for local technicians, engineers and managers. Joint ventures with TNC enabled some of the largest firms in Korea to enter the business, while OEM and ODM arrangements later enabled many latecomer firms to build technological capabilities and secure international market outlets.

The four Dragons exhibited a wide variety of policy approaches which resulted in significant differences in industrial structure, corporate strategy, firm ownership and methods of technology acquisition. Korea progressively reduced its reliance on FDI by internalizing capabilities within the three chaebols and by

entering long term OEM alliances with, mainly, Japanese TNCs. Conversely, Taiwan and Hong Kong relied on a multitude of small and medium domestic firms, showing that the disadvantages of small firm size can be overcome. Again in contrast, Singapore depended almost entirely on FDI for the development of its electronics exports and the assimilation of technology.

There were a number of common factors essential to successful electronics development in the four Dragons:

1. The macroeconomic context must produce long stability and confidence. The literature shows that sound monetary policies, high domestic savings and export-led industrial policies provide a stimulating economic context for industrial development in each of the four countries (World Bank, 1993). Of course, such factors cannot explain the diversity of strategies towards technological and industrial development evident in the four Dragons. The Schwartzman paper, however, clearly indicates damage that instability has and is producing throughout the institutional structure that supports S&T.

2. The existence of skilled local entrepreneurs was essential to industrial development in three of the four NICs. In the absence of such enterpreneurs, Singapore chose to rely on foreign TNCs. A high degree of domestic competition was apparent in each case, despite plurality in ownership and industrial structure.

3. A further success factor was each government's investment in basic education as well as craft, technical and vocational engineering courses directed towards the needs of industry. Furthermore, at the corporate level, the coupling of technological learning with export demands enabled latecomers in each economy to climb the technological ladder and to progressively reduce the technological gap between themselves and the international market leaders. Recently, as latecomer firms' capabilities have increased, technology partnerships with leading American and Japanese companies have provided a means for acquiring highly advanced electronics technologies. Some of the latecomers have purchased overseas high technology firms to acquire skills and to access distribution channels directly.

The simple model put forward provided a useful first approximation for understanding the dynamics of market and technology development in the Dragons. As well as highlighting the market-technology linkage, the model suggested that latecomer firms tended to start with simple assembly and manufacturing tasks and, once mastered, proceeded to more complex design and development work. The evidence confirmed the view that technological learning is a cumulative, incremental process. The model also drew attention to the contrast between latecomer firm strategies and those implied in conventional models of innovation. In contrast with "Western" innovation models, latecomer firms begin with mature, standardized technologies and gradually work their way "backwards" along the product life cycle towards new designs, process development and research.

One question which deserves further investigation is whether or not latecomer firms "innovate" as they learn the technology of electronics. The evidence suggests that firms do innovate, but in ways constrained by their latecomer structures and status. Innovation appears to be incremental rather than radical, while the focus of innovation is process, rather than product (at least in the initial stages). This type of continuous improvement pattern may have helped narrow the technology gap between East Asian firms and the market leaders, enabling them to "catch up" rather than just "keep up". However, more in depth research is needed to establish the breadth and depth of innovation in the latecomer electronic firms.

Conclusions

Schwartzman describes the new realities facing Brazil under two main headings:

(a) changes in the role of science and technology in the international scene; science, technology and industry more closely integrated;

(b) changes in the nature and capabilities of the Brazilian State; hindered by the problem of institutional and financial stability.

New policies required

The new policy should implement tasks that are apparently contradictory; to stimulate freedom, initiative and creativity of the researcher, while establishing strong links between their work and the requirements of the economy, the educational system and of society as a whole; and to make Brazilian science and technology truly international, while strengthening the country's S&T capabilities. To achieve this, the individual researcher, and his research unit or laboratory, should be freed from bureaucratic and administrative constraints, and stimulated to look for the best alternatives, in the country and abroad, for the use and improvement of his competence. This requires, in turn, a competitive environment based on public incentives and private opportunities that rewards achievement, increases the costs of complacency and underachievement, and gears a substantial part of the R&D resources toward a few important and strategically selected goals.

More specifically, the new policy should include the following tasks:

(a) increase links between science and the productive sector;

(b) create two different markets, one for academic science, another for applied technology;

(c) increase links between science, technology and education;

(d) invest heavily in the development of innovative capabilities of the production system;

(e) support a few integrated projects;

(f) create conditions for Brazil's participation in international programmes;

(g) increase institutional flexibility and accountability (through more exhaustive peer review).

How does the model adumbrated above relate to these new realities?

The "reverse-linear" model proposed above imposes the idea of integrationist policy — of what has been called innovation policy. The first thing that the model draws attention to is the need to develop innovation policy on a sectorial basis. It would be a useful preliminary exercise to try to place each sector at its appropriate stage in the model. This would provide guidance as to whether S&T policy in particular cases ought to place priority on developing the technical infrastructure or the R&D infrastructure. If we presume that all firms in whatever sector will, one way or another, be latecomer firms, it is extremely important to know how "late" a latecomer they are. If they are late developers then the development of the technical infrastructure must receive priority. The reverse-linearity suggests that the lower strata of the educational system must be the priority. They are essential to define which sector is to begin to play a part in the technology-market interactions which characterizes the innovation process.

The new ingredient that I would add to Schwartzman's considerations lies in the centrality of learning. This will affect policies which aim to promote links between science, technology and education. Increasing the links between science and the productive sector, must begin first at the technical level if the firms are in the first stages, and then move on to the provision of R&D and design support. The strenghtening of the technical infrastructure must come first, instead of preconditions that require a very sophisticated higher education sector or capability in fundamental research.

By identifying where each sector is in the model, it becomes possible to specify which sets of firms need explicit R&D support and *a fortiori* which areas of scientific and technological research ought to be strengthened. If firms are in the first two stages they do not need R&D support. It is unlikely that they could appropriate it. Classifying firms in this way might also make it easier to identify the strategic links with the international scientific community which need to be developed and perhaps even suggest which particular demonstrator projects ought to be launched. In brief, using the staging approach increases the probability that policy will be appropriate to the need of particular firms.

The recommendation which gives me the most trouble is the idea of developing separate markets for science and technology. It is feasible, perhaps even desirable, if most of the latecomer firms are in the early stages of technology-market process. However, in all the advanced sectors, as Schwartzman acknowledges, science is produced in the context of application and so the two markets interpenetrate. In such sectors it would be regressive to try to keep separate what broader markets has already begun to integrate. For the rest, however, it may well be necessary to have "particularized" markets which in terms of institutions and reward systems reflect the charateristics of particular sectors.

The outcome of all these policies would be to produce distinctive scientific and technical competences in Brazil. It is in the nature of contemporary knowledge production that such competence is both highly specialized and local. It is the job of government to broker that expertise in the wider international community.

Table

Stages of marketing and technology assimilation

Marketing stages	Technology stages
1. Passive importer-pull Cheap labour assembly Dependent on buyers for distribution	Assembly skills, basic production capabilities Mature products
2. Active sales capacity Quality- and cost-based Foreign buyer dependent	Incremental process changes for quality and speed Reverse engineering of products
3. Advanced production sales Marketing department established Starts overseas marketing Markets own designs	Full production skills Process innovation Product design capability
4. Product marketing push Sells directly to retailers and distributers overseas Builds up product range Starts own brand	Begins R&D for products and processes Production innovation capabilities
5. Own brand push Markets directly to customers Independent distribution channels, direct advertising Strong market research	Competitive R&D capabilities R&D linked to market needs Advanced product/process innovation

Source: Hobday, 1991.

Notes

1. Building on the research of Hone, Wortzel and Wortzel (1988) put forward a simple marketing scheme to show how NIC exporters graduate from supplying labor intensive assembly services to exporting advanced goods into foreign markets. Their seminal study is based on interviews with locally owned firms in three Asian Dragons (Korea, Taiwan and Hong Kong) as well as Thai and the Philippines. Covering three export industries (consumer eletronics, athletics footwear and clothing), it is one of the only studies which systematically analyses the importance of export marketing to firms' growth in East Asia. Wortzel and Wortzel were not concerned with the technology dimensions of firms' development. However, it is likely that as firms accumulated marketing skills they also learned to to meet increasingly sophisticated customer needs and to capture the higher level value-added stages of production.

2. An important background study carried out in the early seventies (Hone, 1974) showed that the main source of export-led growth in East Asian countries was not foreign TNCs but domestic firms, spurred on by foreign buyers from Japan and the USA. The large Japanese buyers, including Mitsubishi, Mitsui, Marubeui-Ida and Nichimen, set up operations in Asian NICs to purchase production capacity as wages rose in Japan in the early sixties. American retailers soon followed: these included J. C. Penney, Macy's, Bloomingdales, Marcor, Sears Roebuck and others. These large buyers were very important for the growth of local firms, often placing orders for 60 to 100 per cent of the annual capacity of exporting firms in electronics, as well as clothing, footwear and plastics. Large numbers of small foreign buyers were also very important to the export-led strategies of latecomer firms.

3. At the time of Wortzel and Wortzel's research in the late 1979 most NIC exporters in electronics had reached stage 4 (clothing, footwear were further behind). Although many firms had taken control of local marketing, product design and quality, they had yet to establish their own brand names. Wortzel and Wortzel believed that stage 5 was "largely theoretical" in the NICs. Today, however, Korean firms such as Samsung and Goldstar have established well-kown brand names in some areas. Taiwanese market leaders such as Acer and Tatung have also begun to establish brand names and to manufacture abroad. However, most latecomer firms are behind the leaders in marketing and remain dependent on foreign buyers and TNCs for marketing. For example, Cal-Comp of Taiwan is today the world largest producer of calculators and fax machines. Although it is virtually unknown in the West, Cal-Comp produces rough 80 per cent of Japanese Casio calculators under OEM.

4. Since Gerschenkron's classic work (1962) on patterns of 19th century European industrialization, many studies have examined the phenomenon of latecomer industrialization. However, as with other studies of industrialization noted in the introduction, the contribution of firms, their origins, strategies, structures and methods for acquiring technology are not dealt with on the latecomer literature. This section, therefore, outlines a simple market-technology model for the latecomer firm, based on existing studies of market entry and technology development.

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